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APPLICATION SOFTWARE for TESTING and EVALUATION of ASPHALT MIXES

COMPUTER-CONTROLLED OPERATION OF THE MTS 810 TESTING SYSTEM

**MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE**

APPLICATION SOFTWARE
for
TESTING and EVALUATION of ASPHALT MIXES



by

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APPLICATION SOFTWARE for TESTING and EVALUATION of ASPHALT MIXES COMPUTER-CONTROLLED OPERATION OF THE MTS 810 TESTING SYSTEM

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Abstract:	Seven custom computer application programs have been developed to provide automatic control of bituminous mix testing, using the servohydraulic Materials Test System (MTS Model 810). This software package conforms to the: - specific test methods outlined in the Ministry's "Bituminous Material Characterization Manual", - MTS testing station series of 468 Test Processor, the Digital PDP-11/23 Plus microcomputer, and other related equipment and devices. Documentation is prepared for each of the programs, containing summary of test procedure, the source code listing, program control functions, user's operation guide, an example of program output and other useful information. This report describes the testware and elements that are common to all the automated testing procedures documented separately as mentioned. The system user is provided with essential information on computer terminal setup, definition of terms, measurement principles, using the programs, and on transferring of test results to an IBM-compatible computer. Several appendices are included to illustrate the MTS BASIC hardware configuration, system configuration files, the key test data format and codes used, etc..		
Résumé :	Sept programmes d'application informatisés ont été élaborés pour permettre l'essai automatique des mélanges asphaltiques à l'aide du système d'essai de matériaux MTS 810. Ce progiciel : - est conforme aux méthodes d'essai décrites dans le "Bituminous Material Characterization Manual" du ministère; - est compatible avec le processeur de série 468 de la station d'essai MTS, le micro-ordinateur Digital PDP-11/23 Plus et d'autres appareils connexes. On a préparé de la documentation sur chaque programme, y compris un résumé de la méthode d'essai, une liste des codes de sources, une description des fonctions du programme, un guide de l'utilisateur, un exemple de résultats obtenus avec le programme et d'autres renseignements utiles. Le présent rapport décrit le logiciel de test et les éléments communs à toutes les méthodes d'essai automatisées, documentées séparément. L'utilisateur y trouvera des renseignements essentiels sur l'installation d'un terminal informatique, la définition de termes, les principes de mesure, l'utilisation des programmes et le transfert des résultats des essais à un ordinateur compatible avec IBM. Plusieurs annexes sont incluses pour illustrer la configuration du matériel MTS BASIC, les fichiers de configuration du système, le format des principales données de l'essai, les codes utilisés, etc.		
Keywords:	Test software, test methods, MTS Basic, bituminous mixes, laboratory testing, computer-controlled test systems, program documentation.		
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1. INTRODUCTION

The servo-hydraulic Materials Test System (MTS Model 810) was installed in the Bituminous Evaluation Laboratory in early 1987. The system is capable of generating load and displacement control signals for some basic data acquisition and display. It did not include, however, any testware nor accessories, attachments, and instrumentation necessary for complete testing of specimens, transmitting of test load, and measuring of resulting displacements. The computer terminal and MicroPDP-11/23+, which came with the MTS system, consists of only hardware components and the RT-11 v. 5.2 system software. The RT-11 operating system is complemented with a high-level MTS 773 Series MU BASIC interpreted programming language, external function drivers, and some utilities.

In order to utilize the system fully for a variety of standard and nonstandard tests, several test softwares were developed to automate the testing for bituminous mixes. The programs have been written using the MTS 773 MU BASIC language (version 02.11) and some elements of the remote graphics instruction set (ReGIS) specific for the VT240 video display terminal. This task was essentially accomplished during 1987 through 1989. After 1989, on the basis of experience gained from numerous testing, some refinements were made either to the user-computer interface or to the testing system to ensure better user-friendliness and functionality of the following programs.

- Resilient Modulus Test
- Creep Compliance Test
- Flexural Fatigue Test
- Direct Tension Test
- Dynamic Modulus Test
- Unconfined Compression Test
- Indirect Tension Test

Each of these programs is documented in separate reports in two parts - program documentation and user's guide.

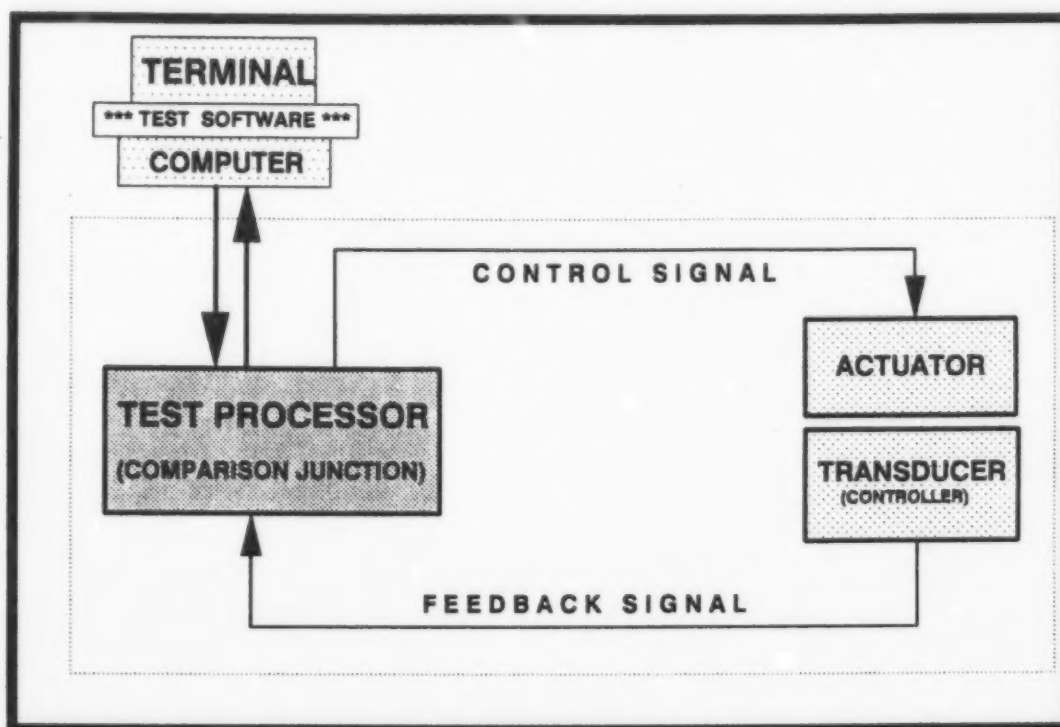
However, this report describes only these testware and elements that are common to all the automated testing procedures. The system provides users with basic understanding of the MTS testing station configuration with guidance on terminal setup, measurement principles, and on using the testing programs.



2. MAIN COMPONENTS OF THE MTS CONTROLLING HARDWARE

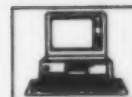
2.1. TEST PROCESSOR

The MTS 810 testing system is an automated station, i.e. a computer controlled system as illustrated by the following model:



Although the system can be operated using the MTS Function Generator, i.e. in local mode, its capabilities cannot be utilized as fully as in an automated (remote) mode. This makes the computer control an essential feature of the system. A flow chart of the control elements is shown in Appendix A.

The heart of the controlling hardware is the 468 Test Processor. As shown in the appendix, it consists of several electronic boards:



- micro segment generator,
- data acquisition device,
- D/A converter,
- digital I/O,
- programmable clock,
- communications link.

The test processor is situated between the ANALOG CONTROLLERS of the system and the COMPUTER (central processor) by which software programs provide control and data collection for the test system. This configuration when combined with the MTS BASIC software external functions, determines the overall capability for automation of the system.

2.2. TERMINAL, COMPUTER AND PERIPHERAL EQUIPMENT

The test processor responds to the computer commands through a so-called Q-Bus to Device Bus Converter. The converter links the computer bus with the device bus. The computer CPU incorporates 512 Kb of standard memory and provides with 22-bit addressing capability. It is housed in one floor-mounted cabinet together with a mass storage device (Winchester disk of 10 MB capacity) and a dual floppy disk unit.

A user of the automated system interacts with the computer by means of a controlling video terminal VT-240 (with standard graphics capabilities and setup options). Its three major components are: a monitor, a system box, and a keyboard.

The computer controls these hardware modules: command generation devices, data acquisition devices, and test function devices.

2.3. MTS CONTROLLERS

Control of a system channel in the servo loop test system is provided with an AC or DC Controller. A full-scale operating range of each controller is determined by the input command (which is in ± 10 V range) and the range cartridge selection. Various range cartridges are provided for each available controller.



The operator selects a desired operating range and installs an appropriate range cartridge or cartridges prior to a test. The lowest range cartridge above the highest expected value of the associated transducer output should be selected. The closer the range cartridge and the expected test range, the more accurate the test results will become.

3. ACTIVATION OF THE COMPUTER SYSTEM: CONFIGURATION FILES

When the computer is switched on and activates the terminal, the operating system RT-11 is booted up from the hard disk and commands can be entered from the terminal.

The first commands to be entered at a dot prompt are *DATE* and *TIME*. These commands show you the system date and time, which are used for record keeping purposes. If displayed values are not correct, you should set the system date and time by entering the two commands in the following format:

.DATE dd-mmm-yy (e.g. DATE 29-FEB-92)

.TIME hh:mm:ss (e.g. TIME 14:49:35)

Now the system is ready to activate the MTS BASIC by using one of these commands: **.\$@MTSBAS** or **.R MTSBAS**. At this point, a decision must be made as to configuration files. There are three configuration files, stored on the hard disk, which contain information about the interrelationship between MTS BASIC language components and the TEST PROCESSOR devices; they combine the hardware and software resources to produce a desirable system operation. These three files are:

- CNFDEV.D00 ⇒ Device configuration file. It identifies the Test Processor, its electronic boards (devices), the number of physical channels on each device, and the bus address at which each device can be accessed.
- CNFSTA.D00 ⇒ Station configuration file. It identifies the electronic devices that support the testing station. It also identifies the data and control channels available to MTS BASIC programs.
- CNFSFT.D00 ⇒ Software configuration file. It identifies the terminal, the available computer-related storage devices, specifies system buffers and system channels to be available at one time, the number of blocks of memory that can be open for a file.



The contents of these files is shown in Appendix B. It reflects the system configuration as of the February 1991.

If there are changes required in any of the files, enter the following command at the dot prompt:

R MTSBAS

and respond correctly to the displayed prompts/questions. See "RECONFIGURING THE SYSTEM" (Section VI) in the MTS Software Manual for details.

Normally, the files does not need to be modified and the command:

\$@MTSBAS

only is entered. When the prompt *Ready* appears, the MTS BASIC, Version 2 interpreter is now loaded, and any application written according to the MTS BASIC language can be run.

4. TERMINAL SETUP OPTIONS AND MTS BASIC

VT240 Terminal provides set-up options that can be selected both at the system dot prompt and under MTS BASIC environment. They can also be changed from within MTS BASIC programs.

In some cases, it may be necessary or desirable to change some of the terminal settings by pressing the *SETUP* key on the keyboard, and using the cursor arrow keys and toggle choices to select desired options.

The following are some of the features/options:

In Set-up DIRECTORY

- CLEAR DISPLAY -** clears the monitor screen
- CLEAR COMM -** aborts printing and clears keyboard buffers

In DISPLAY Set-up

- AUTO WRAP -** selects if display text automatically wraps onto the screen
- CURSOR STYLE -** selects block or underline cursor style displayed in text mode



In GENERAL Set-up

MODE - sets the terminal to operate with various capabilities (VT200 Mode, 7-bit is the default)

In PRINTER Set-up

MODE - selects a printer operating mode (*Normal Print Mode* is the default)

PRINT - selects between printing Full Page and Scroll Region for a text print operation (default is *Full Page*)

In GRAPHICS Set-up

GRAPHICS PRINT - selects the size of the graphic image printed by a printer: COMPRESSED (15 by 7.5 cm), EXPANDED (30 by 20 cm), or ROTATED 90° (20 by 30 cm)

Word of caution: ONLY CHANGE SETTING WHEN DESIRED RESULTS ARE ASSURED.

To exit the SETUP, touch the SETUP key again, or while in the SETUP Directory, move the cursor to the *Exit Set-up* option and press *Enter* key.

MTS BASIC offers a wide variety of support for text and graphics, including access to the Remote Graphics Instruction Set (ReGIS) with the VT240 terminal. A complete MTS BASIC language, Version 2, installed currently on the MicroPDP-11/23+ includes the following modules:

773.00 Foundation BASIC

773.59 Communications Link - Send/Receive Support

773.86 Text Support Functions Support

Video Terminal

773.75 Software Development Modules Support

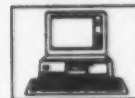
Edit Enhancements

Cross Reference Generator

Tabular Output Formatting

773.94 Data Storage in Upper Memory Support

Virtual Array Support

**773.74 Configuration Status Support - Configuration Warning**

Station Information

Configuration Information

773.41 Advanced Data Acquisition Support

xxx.xx Graphics Support

773.81 4010 Terminal Support**773.88 VT240 Terminal Support****773.73 Test Program Function Support**

Fatal Error

Integer Date

Time Out Interrupt

BASIC to RT-11 Command

Advanced Keyboard Interrupts

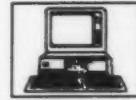
File Size from BASIC

xxx.xx Mode Switch - 458 Series Support - 458 Mode Switch Function

773.31 D/A Converter Support**773.34 Advanced Test Command Support - Micro Segment Generator****773.62 MTS Digital Input/Output - 468.62 Support****5. TERMS, UNITS, AND DEFINITIONS**

The operation of MTS testing system is quite complex, especially when it is described in specific technical jargons. However, it is important to know some of the elementary terminology and technical definitions in order to better understand how the system works to proper analysis of test results. The most frequently used terms are explained below.

BANDWIDTH - See NOISE CORRECTION FACTOR.

**BUS**

- A cable providing communication lines for addressing the computer memory and for bidirectional data transmission.

(MICROPDP-11 SYSTEM USES AN ASYNCHRONOUS BUS FOR COMMUNICATION AMONG THE CENTRAL PROCESSING UNIT, MEMORY, AND THE I/O MTS DEVICES. THERE ARE 22 ADDRESS LINES IN THE BUS, CORRESPONDING TO 22 BITS OF THE PDP-11 PHYSICAL ADDRESS SPACE. SIXTEEN OF THESE 22 LINES ARE SHARED FOR DATA TRANSFER.)

CALL

- Assembly language routine provided by the MTS software system, and normally activated from within the MTS BASIC language.

CHANNEL

- One logical connection with a location *external* to the computer, represented by a test station.

**DATA ACQUISITION
PROCESS**

- Automatically controlled and relatively fast data collection that includes detection, conversion, and saving of data from selected analog-to-digital (A/D) channels in a predefined mode/type. Each mode collects a particular type of data, e.g. peaks and valleys, range crossings, zero crossings, etc..

(DATA RETURNED BY DATA ACQUISITION FUNCTIONS IS IN BINARY FORMAT AND MUST BE CONVERTED INTO ENGINEERING UNITS (VOLTS) PRIOR TO ANY DATA ANALYSIS OR PRESENTATION. THE ONLY EXCEPTION HERE IS THE IMMEDIATE FUNCTION (ADIMMED) WHICH RETURNS DATA IN NORMALIZED ENGINEERING UNITS (N.E.U.). THOSE DATA CAN EASILY BE EXPRESSED IN PROGRAM ELECTRICAL OUTPUT USING THE MULTIPLICATION FACTOR OF 10.)

The concepts of a *noise* and a *bandwidth* are used in data acquisition processes. They are directly related to the accuracy of measurements.

DEVICE

- Name by which the hardware is referenced outside the context of the system software, e.g. Micro Segment Generator.

N.E.U.

- See NORMALIZED ENGINEERING UNIT.



- NOISE (NOISE BAND)** - Electrical noise, i.e. unwanted electrical signals, which produce undesirable effects in the circuits of control systems where they occur. Typical sources of the noise are: switches, heavy current conductors, fluorescent and neon lights, some connectors and resistors, etc.. The noise can be controlled to some degree but cannot be eliminated, so before a specific data acquisition process or program is executed, the value of "noise band" must be determined and used - as required - as a part of definition for that process or program.
- NOISE CORRECTION FACTOR (=BAND WIDTH)** - A value specifying the *reversal level* of electrical signal, i.e. determines when a value is to be considered a PEAK or a VALLEY, or determines when the next point will be recorded (during a level-based data acquisition process).
- NORMALIZED ENGINEERING UNIT** - A conventional unit expressing the program electrical output of ± 10 Volts in terms of ± 1.0 . Its decimal equivalent at 16-bit D/A resolution is $\pm 32,752$.
- PEAK** - A signal value recorded as a *maximum within* a predefined waveform in accordance with a specified reversal level (NOISE BAND) that determines when a value is to be considered a peak.
- STATION** - The site at which the software's real time control and testing is apparent.
- TASK** - Operating features with allocated memory space that execute the MTS BASIC program.
- TERMINAL** - The interface between a user and a task.
- UNIT (OF MTS HARDWARE)** - Part of a device, a device, or several devices (e.g. A/D subsystem). Constituents of a unit are usually acted upon simultaneously, e.g. channels on bus devices are grouped into units because of logical connections between the channels.
- VALLEY** - A signal value recorded as a *minimum within* a predefined waveform in accordance with a specified reversal level (NOISE BAND) that determines when a value is to be considered a valley.

**WAVEFORM**

- A segment or a group of segments with corresponding specified end levels, forming a desired prototype of analog action for the MTS electro-hydraulic system.

(All entries specifying end levels at any channel in the Micro Segment Generator calls are expressed in Normalized Engineering Units (N.E.U.).

All entries specifying the duration/frequency of a waveform are expressed as:

- FREQUENCY, in Hz for one cycle (= 2 segments); theoretical range is 0.00024 + 1.000 Hz;
- TIME, in seconds for a single segment; theoretical range is 0.5 ms + 2097.15 s;
- RATE, in fraction of full scale per second; theoretical range is 2.91184×10^{-8} + 62.5315 s^{-1} .

Pause between segments in waveform generation is 200 + 300 microseconds, so effective frequency is always lower than the specified one in a call.)

WAVEFORM GENERATION FUNCTION(S)

- A set of MTS data processing commands providing mechanism for specifying the predefined segments (wave slopes) to be generated by the Micro Segment Generator or for defining a custom wave of desired shape. Immediate function is also available for generating a single wave segment. Waveforms are generated by Micro Segment Generator without intervention by the host computer.

6. USING TEST PROGRAMS

Users of the programs should be aware of the MTS system safety practices. The most essential precautions are described in Appendix G.

All major test programs are included in a menu callable from MTS BASIC environment at *Ready* prompt.

To invoke the testing software logo screen type 'RUN TESTS' and touch *Return* key, and to display the main menu and select a desired test program press *Return* once. Each of the programs has its own menu. The following consecutive steps and on-screen instructions should be followed:



- enter required information and test specifications; check readiness of the testing machine and instrumentation involved,
- run the test; check frequently if the servohydraulic system remains stable throughout the testing procedure; when an instability develops use available controls to abort testing,
- obtain hard copy of test results and test report,
- perform preliminary evaluation of results and decide on acceptance or rejection,
- save the results, if accepted, to a hard disk.

A hard copy of the screen display can be obtained at any stage during testing in two ways:

- by pressing *PRINT SCREEN* key, or
- by pressing *Shift + PRINT SCREEN* keys simultaneously.

The second option will send the screen image (both text and graphics) to the printer.

You can also direct all the screen output to the printer by pressing *Ctrl + PRINT SCREEN*. To exit this AUTO print mode, the same keys must be pressed again (when printer stops printing).

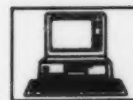
There are several other print operation controls which can be implemented both directly at the terminal and within MTS BASIC program. They are not intended for use in the test programs and are not discussed here. Details can be found in "VT240 Series Programmer Reference Manual" by Digital Equipment Corporation.

Upon exiting a test program, the test-related data are not deleted automatically. They remain in computer memory until the same or a new program is loaded. This allows the data to be re-examined if necessary.

7. TRANSFER OF TEST RESULTS TO AN IBM-COMPATIBLE COMPUTER

Data can be transferred from the MicroPDP-11 directly to any IBM-compatible microcomputer using a null modem cable and data communication software at both ends.

Physical link should be established between the two computers: serial port COM1 at the IBM-compatible (e.g. COMPAQ) to a connector A1 on the MicroPDP-11 system I/O panel. The following steps enable the transfer of results between computers.



AT THE IBM-COMPATIBLE STATION

- ① → Select and run **PROCOMM+** from the Main Menu.
- ② → Specify a **default path** (if not done yet), using the SETUP utility, for files imported from PDP-11.
- ③ → Select **DIRECT CONNECTION** from General Options menu.
- ④ → Set the following **Transfer Options**: VT102, FDX, LOG-OPEN, ON-LINE.
- ⑤ → Set **Line/Port Options** to: 9600, NO PARITY, 8 BITS, 1 STOP BIT, COM1, CR/LF.
- ⑥ → Touch **PgDn** key to open the line for RECEIVING a file.

AT THE MicroPDP-11 TERMINAL

- ① → When at MTS BASIC prompt, type **RT11** to switch to the system dot prompt.
- ② → Press **Set-Up** key and select **Comm** option in the SETUP Directory. Make sure that the following communications options are set: 9600, NO PARITY, 8 BITS, 1 STOP BIT. Exit Set-Up.
- ③ → Enter **FRUN VTCOM.SAV/PAUSE** at dot prompt; the system responds with *Loaded at 114600*.
- ④ → Enter **LOAD XL=F**, then enter **RESUME** on next line at dot prompt.
- ⑤ → Enter **CTRL-F**; the system responds with prompt: *F>*.
- ⑥ → Enter **CTRL-P**; the system responds with prompt: *TI::VTCOM>*; now link with the other computer is established.
- ⑦ → Enter **FAST** and **CTRL-P** again.
- ⑧ → Enter **SEND**; the system prompts you for the name of a file you want to transmit.
- ⑨ → Enter the **file name** and **extension** and touch *Return* key; the file transfer takes place immediately.
- ⑩ → When scrolling on the other screen is finished, enter **CTRL-Z** to close the file at the other station.

To transfer more files, repeat steps 8 to 10 for each file. To disconnect the PDP-11, enter **CTRL-P** and, at *TI::VTCOM>* prompt, enter **EXIT** and press **Return** twice.



To disconnect the other computer, enter at its keyboard **ALT-H**, and then exit the *PROCOMM+* program to get the Main Menu displayed.

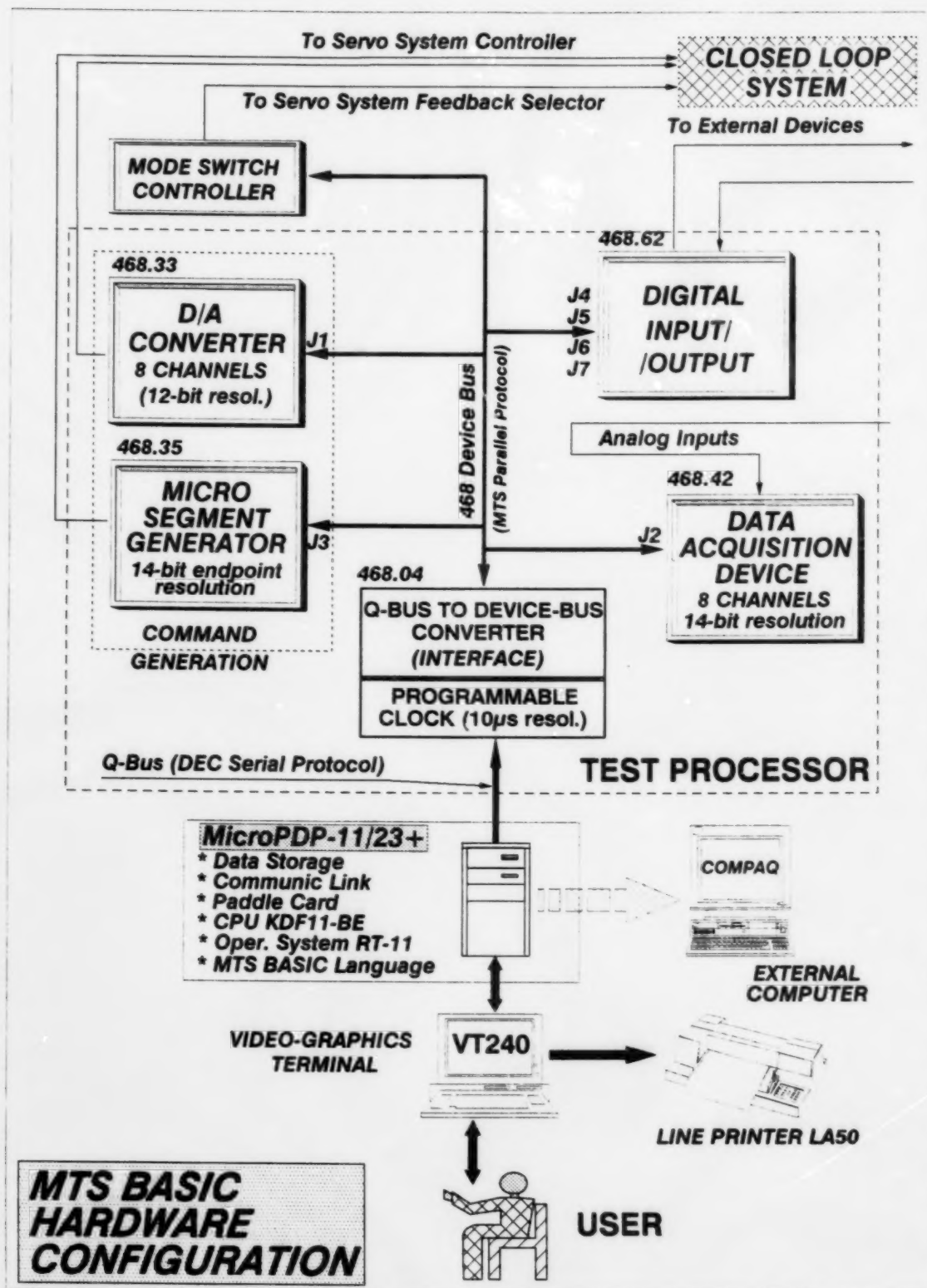
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SYSTEM CONFIGURATION FILES

DEVICE CONFIGURATION FILE

How Many Device Bus Controller Devices [0]? 1

DB#1

Base Address [164000]?

Base Vector Address [000000]?

CSR Address [164002]?

How Many A/D Converter Devices [0]? 1

A/D#1

On which 468 DB Controller [1]? 1

CSR Address [165000]?

Vector Address [000340]?

Number of Channels [1]? 8

First Channel Address [165100]?

How Many D/A Converter Devices [0]? 1

D/A Converter#1

On which 468 DB Controller [1]? 1

CSR Address [165500]?

Number of Channels [1]? 8

First Channel Address [165700]?

How Many Programmable Clock Devices [0]? 1

Clock#1

On which 468 DB Controller [1]? 1

CSR Address [164020]?

Vector Address [000120]?

Is this a BCD Clock [N]?Y

Enter 1 - 1 micro, 2 - 10 micro sec freq?2

How Many Micro Segment Generator Devices [0]? 1

FG#1

On which 468 DB Controller [1]?

CSR Address [165400]?

Vector Address [000320]?

How Many Digital Output Devices [0]? 1

Digital Output#1

On which 468 DB Controller [1]?

CSR Address [164500]?

Is the Digital Output being used with a 458 controller [N]?Y

How Many Digital Input Devices [0]? 1

Digital Input#1

On which 468 DB Controller [1]?

CSR Address [164500]?

Vector Address [000140]?

Is the Digital Input being used with a 458 controller [N]?Y

How Many 458 Mode Switch Devices [0]? 1

MD#1

End Device Configuration

STATION CONFIGURATION FILE

How Many Stations [0]? 1

STA #1.

Each A/D Converter has Two Remote Lines attached to it.

You will be asked the Type of Device attached to each Remote Line.

How Many A/D Converter Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

Enter Number for Type of Device attached to Remote # 1.

1 - Clock, 2 - External, 3 - Not Hooked?1

Enter the Physical Clock # ?1

Enter Number for Type of Device attached to Remote # 2.

1 - Clock, 2 - External, 3 - Not Hooked?3

Enter the # of the Remote Line to be used as the

Primary Remote.

1 - Remote #1, 2 - Remote #2?1

Enter the # of the Remote Line to be used as the

Secondary Remote.

1 - Remote #1, 2 - Remote #2?1

How Many D/A Converter Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

Which Clock Will Run This Station's D/A's? 1

How Many Programmable Clock Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

Minimum Clock Time in # of Ticks [0]?100

How Many Micro Segment Generator Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

Are the micro segment generators on this station
modified for high frequency performance [N]?N

How Many Digital Output Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

How Many Digital Input Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

How Many 458 Mode Switch Logical Units [0]? 1

LUN #1.

Physical Unit #? 1

Which physical D/A controls this

mode switch logical unit [1]? 1

Which physical digital input controls this

mode switch logical unit [1]? 1

Which physical digital output controls this

mode switch logical unit [1]? 1

End Station Configuration

SOFTWARE CONFIGURATION FILE

Enter Available Devices:

? DU0P,1P,2P

?

How Many DL11/DLV11 Terminal Interfaces [0]? 2

DL11 Unit #1.

CSR Address [177560]?

Vector Address [000060]?

Terminal Type [1]? 12

DL11 Unit #2.

CSR Address [176500]?

Vector Address [000300]?

Terminal Type [1]? 10

1474 Words Remaining

System Buffers Specification (Number,Size (Words)):

? 1,256

? 2,128

?

935 Words Remaining

System I/O Area Size (Words)? 32

Number of User Channels? 6

Number of System Channels? 2

Maximum Number of Channels for Unprivileged User? 6

Maximum Number of Blocks in OPEN for Unprivileged User? 100

Default Number of Blocks for OPEN [0]? 10

5917 Blocks Core Available

How Many Tasks [1]? 1

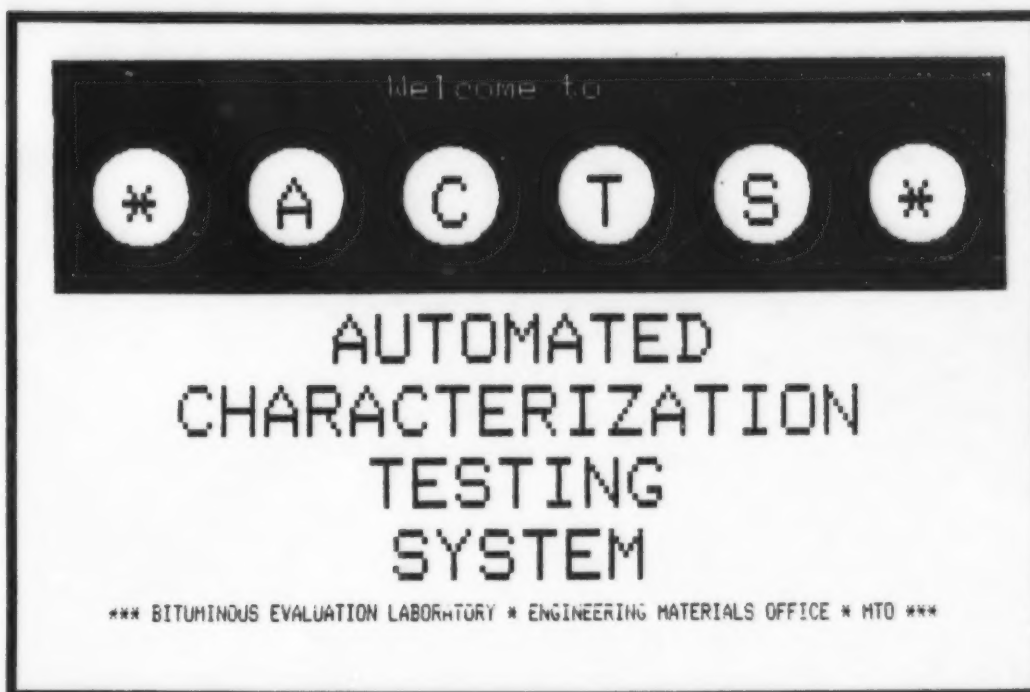
Blocks #1?

Task #1 to Term. # [0]? 1

Station # 1 To Which Task #? 1

End Software Configuration

SOFTWARE SYSTEM LOGO and MAIN MENU



APPENDIX C

• SOFTWARE for AUTOMATED TESTING of ASPHALT MIXES •
• DOCUMENTATION and GUIDE •

SCALE FACTORS for **MTS RANGE CARTRIDGES and LVDTs**

RANGE MARK	FULL SCALE (± 10 V)	SCALE FACTOR
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Stroke Range Cartridges

inches	mm	mm/V
0.5	12.7	1.27
1.0	25.4	2.54
2.5	63.5	6.35
5.0	127.0	12.70

Load Range Cartridges

kips	N	N/V
0.20	890	89.0
0.55	2,446	244.6
1.0	4,448	444.8
5.0	22,240	2,224
10.0	44,480	4,448
20.0	88,960	8,896

Strain Range Cartridges

inches	mm	mm/V
0.01	0.254	0.0254
0.10	2.540	0.254

Linear Variable Differential Transformers (LVDTs)

inches	mm	mm/V
0.795	20.200	2.020
0.123	3.120	0.312

EVALUATION LAB DATABASE

KEY DATA FORMAT

A = alphabetic character
X = digit or character
9 = numeric digit

▲ **BITUMINOUS MIX IDENTIFICATION (JMF):**

A A9 999

Mix Number
Mix Type
Mix Source/Origin

▲ **PAVEMENT SAMPLE IDENTIFICATION:**

A999 999 X99

Contract/Program Id.
Sample Number
Highway Number

▲ **SAMPLE/SPECIMEN IDENTIFICATION:**

A A X99 XA 999

Sample Number
Lab Project Id.
Contract/Program Id.
Sample Type
Sample Source

▲ **LAB TEST IDENTIFICATION:**

AA 9999

Test Number
Test Name

- **DATE FORMAT:** MM DD YY
- **TIME FORMAT:** HH MM SS

SUGGESTED DATA CODES

EVALUATION LABORATORY DATABASE

CODE	ITEM DESCRIPTION	DATA CATEGORY
A01		Contract/External Program/Task (Letter/Digit + Two digits)
A02		
A03		
A04		
AA		Laboratory Project (Letter/Digit + One letter)
AB		
AC		
AD		
L	LAB MIXER	Mix Source (One letter)
F	FIELD PLANT	
R	MIXED IN PLACE (recycl or not)	
S	SURFACE COURSE	
B	BINDER COURSE	
A	BASE COURSE	
H1	HL-1	Mix Type (H or S, + One digit)
H2	HL-2	
H3	HL-3	
H4	HL-4	
H5	HL-3 Fine	
H6	Modified HL-1	
H7		
H8	HL-8	
S1	Dense Friction Course	
S2	Open Friction Course	
S3	Heavy Duty Binder	
S4	Experimental Mix	
H	LAB	Sample Source (One letter)
E	FIELD	
P	PAVEMENT	
C	CORE	Specimen Type (One letter)
D	CYLINDER	
I	BEAM	
M	MARSHALL	
G	GTM	
U	SLAB	
N	LOOSE MIX	
CC	Creep Compliance Test	Test Name (Two letters)
CS	Compressive Strength Test	
DM	Dynamic Modulus Test	
DT	Direct Tension Test	
FF	Flexural Fatigue Test	
RM	Resilient Modulus Test	
GT	GTM Test	
WT	WTM Test	
D	Design	Test Purpose
C	Control	
I	Investigation	
R	Research	

SAFETY PRECAUTIONS **for** **MTS OPERATORS USING TESTING SOFTWARE**

The servohydraulic system can become unstable in some operational situations, especially during adjustments needed from time to time to optimize the system response. Occasional fluctuations of actuator stroke/force can be anticipated as a result of erratic operation of the servovalve (due to e.g. contamination of hydraulic fluid) or errors in test setup (e.g. when adjusting the Set Point and Span controls on a controller).

System operators should be well acquainted with the operation safety practices provided in the appropriate manuals. Among the many precautions, the following points should be noted at all times.

- **STAY CLEAR OF ANY POTENTIAL CRUSH POINTS !**
- **DO NOT MAKE MECHANICAL OR ELECTRICAL ADJUSTMENTS TO SYSTEM COMPONENTS WHEN TEST IS IN PROGRESS.**
- **NEVER TOUCH SPECIMENS OR EQUIPMENT WHILE THE SYSTEM IS OPERATING.**